

*7-3-12 DELIBERATIVE DRAFT report of the Environmental Economics Advisory Committee. This draft is a work in progress. It does not represent the consensus view of the Committee. It has not been reviewed or approved by the chartered Science Advisory Board and does not represent EPA policy. DO NOT CITE OR QUOTE*

EPA-SAB-12-xxx

The Honorable Lisa P. Jackson  
Administrator  
U.S. Environmental Protection Agency  
1200 Pennsylvania Avenue, N.W.  
Washington, D.C. 20460

Subject:

Dear Administrator Jackson:

TO BE WRITTEN

Sincerely,

Dr. ....  
Chair  
Science Advisory Board

Dr. ....  
Chair  
SAB Panel on ...

Enclosure

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## **Acronyms and Abbreviations**

## 1. EXECUTIVE SUMMARY

To be developed.

## 2. INTRODUCTION

### 2.1. Background

### 2.2. Charge to the Committee

## 3. EVALUATING THE METHODOLOGY

### 3.1. Literature Review (David Zilberman)

**3.1.1. Section 2 of the report summarizes existing retrospective cost studies. Have we adequately summarized the existing literature or have we mischaracterized it in some way? Are you aware of any studies we have missed? Have we captured key take away messages offered by this literature? How can this discussion be improved?**

If we interpret the question narrowly, then clearly the section summarizes the nature and main results of the literature. The main finding of the literature is that there is a tendency of ex ante studies to overestimate the cost of adjustment to environmental regulation, but it is not across the board and there are studies that actually show that costs increase. The emphasis on studies on the Title IV of the 1990 Clean Air Act Amendments (CAAA) was especially appropriate because it identified the main forces that affect the adjustment to regulations and what the causes of deviation from ex ante to ex post. The study by Popp (2003) is especially insightful and an excellent reference.

Had the authors taken a broader perspective on this question, they might have begun with a conceptual framework. In principle, ex ante studies are an estimate of something that will happen in the future and as such, it is the sum of expected outcome plus the error term. If the ex post estimate is the true cost (or the actual true cost), then we can divide the difference between the ex ante and ex post to bias of the estimate plus an error term. Then, the role of analysis both in the literature review and later on, is to understand what the biases are and what random effects may be causing the difference.

A richer analysis might be achieved by first forming a hypothesis regarding the differences between ex ante and ex post, then reviewing the literature in this light. There are several hypotheses about the causes of differences between ex ante and ex post estimates. Strategic behavior by regulated agents is one such hypothesis as firms cite high costs in the hopes of avoiding or weakening regulations. The other hypothesized cause is technological change as firms find less costly means to comply with regulation. This phenomena is frequently underestimated, especially in response to regulation. Other issues that may result in bias are related to issues of enforcement and compliance and better understanding the

structure of the problem. Exploring these hypotheses before surveying the literature might have yielded a richer analysis.

One study that is quite insightful from Europe that wasn't mentioned is by (Bailey, P.D.; Haq, G.; Gouldson, A., 2002). This study raises the issue of strategic behavior as well as adjustment in terms of technology, innovation and implementation that may be the cause for the gap.

In sum, the RCS provides a decent literature review but more insight could be gained by starting with a conceptual analysis of factors that may affect the gap. A survey of the literature is best guided by some basic hypotheses deriving from a conceptual analysis. Research problems are best addressed with a conceptual model before surveying the literature.

### **3.2. Potential Reasons Ex Ante and Ex Post Cost Estimates Differ (Jinhua Zhao)**

#### **3.2.1. Section 3 of the report briefly describes potential reasons ex ante and ex post estimates might differ. Have we accurately described the various hypotheses? If not, how can this discussion be improved? Are there other hypotheses that should be included or considered?**

The report does a good job in amassing and explaining the variety of reasons for discrepancies between ex ante and ex post cost estimates. It lists such factors as industry incentives to overstate their costs in order to influence policy to their favor, induced innovation after implementation of regulations, changing market conditions over time such as the reduction in costs of transporting low sulfur coal in SO<sub>2</sub> regulation, etc.

The report provides a rather exhaustive list of factors that are prone to causing wedges between ex ante and ex post cost estimates. My main comments are regarding the grouping and classification of these factors. For some factors, the direction of the ex ante and ex post differences can go both ways, but for others, there is strong theoretical (and sometimes empirical) argument for the differences to go one direction only. It might be easier to "correct for" some differences but not for others. An alternative classification scheme to highlight these features is suggested below.

- Ex ante and ex post differences due to inherent uncertainties. Fundamentally ex post costs are dependent on *realizations* of states of nature, while ex ante estimates represent the best effort to estimate the *distribution* of states of nature. As such, differences, even large differences, are genuine features of imperfect information and are hard to correct. This kind of difference can go both ways, but if the ex ante distribution is skewed, the ex post realizations are asymmetrically distributed around the ex ante mean, leading to a higher probability of the ex post realization above or below the mean depending on the direction of the skewness.
- Differences arising from asymmetric information and strategic (mis-)reporting. Since the EPA often relies on the regulated industries for cost information, these industries might have incentive to strategically misreport their private information. Predominantly misreporting takes the form of over-reporting the compliance costs rather than under-reporting especially at the aggregate level. Over-reporting is more likely and of a higher magnitude when (i) more is at stake for the

industries, (ii) the firms are more effectively organized and are more homogeneous, (iii) the degree of information asymmetry is high (e.g., lack of correlated information from objective third parties), and (iv) opposing groups (such as consumer groups) are more pronounced in voicing their opinions. (Note that the four kinds of factors provide, at least theoretically, guidelines about the *drivers* for misreporting and possible ways of correction such as utilizing results from the mechanism design literature.)

- Differences due to firm responses to regulation. This includes induced innovation as well as other gradual responses such as using different inputs. The endogenous firm responses will make ex post costs lower than ex ante estimates.
- Differences due to exogenous shocks. They include exogenous changes in market conditions, in (related but separate) regulations, and in natural conditions after the implementation of the regulation. Ex ante and ex post differences can go either way. Although efforts can be made to better assess future changes, such shocks are difficult to be fully accounted for in ex ante cost estimation.
- Other factors, such as less than complete implementation.

### 3.3. Case Study Methodology (Karen Palmer)

**3.3.1. One goal of this study is to demonstrate the use of different methodologies for obtaining ex-post information on key drivers of compliance cost. While the level of coverage and detail does not match what is typically used in an ex ante analysis in support of a rule, the purpose is to gather enough evidence on key drivers to establish a weight of evidence determination on the direction of ex post costs compared to ex ante costs. These approaches are briefly described in section 4 of the report. Are some approaches more defensible than others? If so, which ones and why? Which of the methodologies are more likely to yield reliable results and why? Or are the merits of each method dependent upon characteristics of the case study to which they are being applied? If some methodologies are more applicable under specific contexts or rule settings, please identify and describe. Are there other methodologies that should be considered for ex post cost analyses?**

The methodology section of the white paper includes an overview of how the rules to be analyzed were selected, a description of the decision rule used to identify substantial differences between ex ante and ex post cost estimates and a discussion of different potential sources of data for the ex post cost estimates and ways to gather pertinent information about compliance activities as well as what would have happened in the absence of regulation. The discussion in this section is largely focused on the last issue regarding identifying sources of cost data and approaches to gathering other information necessary to understand compliance activities. We discuss each of these sections in turn.

Selection of rules for study: The process used to identify the rules has the virtue of starting from a fairly comprehensive list of regulations issued in the past 17 years and the rules for eliminating regulations from the list (small regulations, etc) seems reasonable and unlikely to bias the cost comparison produced by the study. NCEE economists used EPA's Rules and Policy Information Development System (RAPIDS) to identify candidate rules for analysis and focused on economically significant rules (over \$100 million) and recent regulations (since 1995) that were deemed easier to evaluate and to yield more informative answers in part because older RIAs do not have benefit of recent advancements in benefit

1 cost analysis. This process yielded 111 entries from which various rules were discarded, e.g., rules that  
2 were not yet implemented, remanded by the courts, minor amendments to existing rules, rules below the  
3 \$100 million cost threshold and rules deemed too difficult to analyze. This winnowing of the set resulted  
4 in a list of 42 regulations that was vetted internally at EPA to make sure no major rules were missing.  
5 Notably over half of these rules on the list of 42 are air regulations. Also, the RAPIDS data base does  
6 not include regulations applied to chemicals, including pesticides, so one rule in this category was  
7 selected through a separate process. It would be helpful to know the process by which that rule was  
8 selected and how many pesticide (and chemical) regulations might be included if these rules had been  
9 treated similarly to the waste, effluent and air emissions rules included in the larger sample.

10  
11 In the end NCEE selected 10 rules for the RCS study. The five rules include in phase 1 were chosen to  
12 illustrate the use of different data gathering methodologies and a range of regulations (different media  
13 and regulatory forms). For phase 2 the regulations are were selected using a randomized stratified  
14 approach (three air regulations and two other). Randomization is important for, as David Simpson  
15 (2011) points out, most of the rules that have been included in prior ex ante and ex post analyses have  
16 not been randomly selected, but selected because there is data or, in some cases, to make a point about  
17 particular forms of regulation (such as incentive based regulations, or regulations of appliances). As a  
18 result in some cases, it may be difficult to generalize the findings of the prior studies. The main goal in  
19 rule selection should be to rely on choices with the accuracy of cost predictions from ex ante regulatory  
20 impact analyses (RIAs) as well as to cover a range of different EPA regulations (not just air, where  
21 estimated health benefits can be very high so efforts to measure costs precisely may be muted).

22  
23 Discerning Real Cost Differences: In the draft RCS study, NCEE uses a + or – 25% cost difference  
24 threshold to define discernible differences between ex ante and ex post costs. There is precedent in the  
25 literature for using this approach (Harrington et al, 2000, OMB 2005) and it seems to be a reasonable  
26 one as it avoids the assumption of too much precision in either cost estimate.

27  
28 Sources of Cost Data and Related Information: Ideally, to facilitate replicability and independence, the  
29 study would make use of publicly available data to the largest extent possible and would not rely on  
30 sources of ex post cost data that had a vested interest in the findings of the ex ante analysis of  
31 compliance costs (the RIAs). In the absence of existing data, EPA could use an industry wide survey to  
32 gather relevant information from all regulated firms, but such surveys are costly to conduct and getting  
33 firms to respond can be difficult. Historically, data on environmental compliance costs were collected at  
34 the establishment level in the Pollution Abatement Compliance Expenditures (PACE) Survey formerly  
35 conducted annually by the Census Bureau (and in some years funded by US EPA). Regulated  
36 establishments were required to answer this survey by law so non-response was less of an issue.  
37 However, these data have not been collected since 2005 and not on an annual basis for almost 20 years.  
38 Also, the PACE Survey historically did not break out regulatory costs by particular regulations (only by  
39 media and category of cost), so discerning the costs of complying with particular regulations would  
40 likely require additional information to be collected should the survey be reinitiated in the future.  
41 For four of the five rules included in the study, there was insufficient information in the public domain  
42 to estimate ex post costs. Thus for those rules (cluster, MACT II, Arsenic and Locomotive rules) NCEE  
43 had to rely on industry experts, many of whom provided information and expertise to the development  
44 of ex ante costs used in the RIAs. An extensive process was used to identify experts and develop a  
45 questionnaire relevant to each case study. Given the reliance on experts as a source of data, it would be

1 useful for the NCEE staff to consult the literature on expert elicitation to see if there are any particular  
2 statistical issues or techniques that they should be aware of when using this approach.

3 The draft report indicates that more detailed information gathering (including a site visit to a regulated  
4 facility) will be incorporated in phase 2. An important part of that process will be the selection of the  
5 rule for which the site visit will be conducted and identification of the site to be visited. The timing of  
6 the site visit might also be important to the extent that it provides lessons that might be useful in  
7 conducting the ex post cost evaluations of other rules.

8  
9 Methodology for Comparing Rules: An important omission from the methodology section is the  
10 specification of a framework to make the studies of the different regulations more comparable to one  
11 another and provide consistent documentation of the different factors that contribute to differences (or  
12 similarities) between ex ante and ex post cost estimates. Understanding the underlying factors that  
13 contribute to differences in cost is important to drawing conclusions about what factors could have been  
14 anticipated and to the ultimate goal of this study which is to understand what, if any, adjustments to ex  
15 ante cost estimation approaches should be made to provide better predictions of actual costs of  
16 compliance. Understanding these factors does require consultation with industry experts or consultants  
17 about what firms and farms did to comply with regulation and comparing that to what was expected in  
18 the RIAs. Publicly available sources of data will generally not be sufficient for getting this type of  
19 information (unless a prior study has been conducted). This is particularly likely to be true if there are  
20 multiple avenues for compliance with particular rules and if there is considerable heterogeneity among  
21 the regulated firms.

22  
23 One approach to enhancing comparability across the case studies that might be generalizable is that  
24 taken in the locomotive rule case study where each of the underlying components of the ex ante cost  
25 calculation is identified and the difference between each ex ante assumptions and post regulatory  
26 realizations for each component is evaluated to understand its contribution to differences in ultimate cost  
27 estimates. This approach helps to clarify the sources of differences and similarities and could help to  
28 illustrate what factors might be common across regulations and what factors are idiosyncratic to  
29 particular regulations.

## 4. EVALUATING THE CASE STUDY APPROACH

### 4.1. Arsenic Case Study (Jim Shortle and Nick Flores)

#### General Comments:

The arsenic case study has several interesting features. The arsenic regulation affected public water supply systems. Many of the issues that we anticipate, and which Section III of the report discusses, emerge from asymmetric information, competitive behaviors, and innovations that occur within industrial sectors – all of which differ for public systems. Significant reporting requirements and seemingly minimal incentives to misrepresent costs would suggest that public sector ex post studies could generally be conducted with greater ease and accuracy than industrial sector studies. Differences in innovation processes might imply reduced (or increased) mistakes from errors in predicting technological change. Another interesting feature is the high degree of heterogeneity in compliance options available to communities, and apparent heterogeneity of cost-effective strategies across communities based on location specific factors. This feature implies that an understanding of “generic” costs for specific technologies will be of limited value. A compelling ex post analysis must either collect substantial data on actual response, or develop innovative procedures to examine the implications of heterogeneous responses.

The arsenic study reads as a detective story in which the goal is to discover unit costs for various technologies. Several paths are followed. These include the results of demonstration projects, and information obtained from engineering firms, states, and water associations. All of these avenues offer potentially promising ways to glean useful information for retrospective evaluation of ex ante cost estimation. In the end, the investigation is unsatisfying; leading to the conclusion that evidence is insufficient to make any conclusions regarding EPA’s ex ante cost estimates. We would agree.

Overall, the arsenic study has some logical missteps, and some missed opportunities. The study focuses on unit treatment costs for a set of technologies. Unit treatment costs are clearly important, but limited explorations of states indicates that the compliance strategies (the specific technologies and mixes of technologies) selected are even more important. It is these explorations that reveal the heterogeneity of compliance strategies, and it is this heterogeneity that posed the greatest challenge to this case study. The case study may have benefited significantly from greater effort to quantify how communities complied. Given that a small number of cities were found in the ex ante study to account for a very large share of the national costs, the case study might best have been done through ex post studies in a sample of cities.

The RCS does not take the opportunity to explore how analysis of ex ante and ex post cost may differ between regulated entities in the public and private sectors, and potential lessons for the conduct of ex ante studies.

The report does not meaningfully address how the conclusion whether the weight of evidence suggests ex ante cost estimates tend to be higher or lower than ex post costs should be used. A better way to inform and raise cautionary flags regarding bias for future ex ante analyses in order to improve them for public benefit broadly defined as the regulated and those who benefit from the regulation is needed.

Furthermore, there is a glaring disconnect between the hypotheses/concepts outlined in Section III regarding why ex ante and ex post costs may diverge and all the case studies. This disconnect can be attributed to the RCS' primary focus on whether ex ante estimates were biased in one direction or the other.

**4.1.1. Each case study encountered a number of data-related challenges. Comprehensive, detailed data on compliance costs simply was not available for any of the case studies. In some cases, we obtained detailed data on compliance costs for a small segment of the affected industry. In others, we obtained aggregate level data for a larger proportion of the industry.**

**4.1.1.1. Under what conditions are different sources of ex-post data useful/not useful for assessing ex-post costs? In responding, please consider each of the following sources of data: aggregate information from states, data from demonstration projects, detailed data for a small portion of a heterogeneous industry, detailed data on what technologies have been adopted but unit costs for a "typical" entity, expert opinion on costs without external validation, cost estimates from contractors that worked on the original rule.**

**4.1.1.2. Is there anything more we could do with the data we have for these case studies that would yield meaningful conclusions?**

**4.1.1.3. Do you have ideas on ways we can collect better ex-post information for these case studies given limited resources? Are there data sources we have not considered that we could use?**

With regard to this case study and the others, all of these sources of information can be very useful if we move away from the simple question of whether ex ante cost estimates are higher or lower than ex post estimates. A richer set of questions could have elicited valuable information. For example, in conducting the specific ex ante analysis, did EPA consider the control technologies that emerged ex post? Why or why not? Were the technologies nonexistent? Not adequately developed? There may be credible information for answering these questions for the arsenic case study but with the RCS' focus on a single question, this valuable information will not emerge.

Another additional question: Did EPA correctly anticipate how many water systems would be affected by the regulation? The state surveys provide data that could credibly answer this question at least for those specific states. Looking across many retrospective cost case studies, EPA could try to determine if there is a systematic bias regarding this question for classes of regulation such as those for which there is considerable scientific uncertainty over the spatial distribution of contributions.

Of the technologies that EPA did anticipate, were there any unforeseen factors that eventually impacted the realized cost? For arsenic, we learn about water mixing and significant heterogeneity that were overlooked but that turned out to be important in overall costs of compliance.

By broadening the scope of the inquiry beyond a simple more or less question, EPA could gain a more comprehensive understanding of how its assumptions in the ex ante cost analysis may have been right or

wrong. A larger set of questions would have generated more information about factors that caused ex ante estimates to diverge from ex post estimates. It would be useful to ask whether assumptions that did not hold true could have been avoided in ex ante cost estimation. .

Economists would generally be more comfortable with comparing cost estimates using identical ex ante and ex post cost estimation procedures but EPA had to compare estimates that were derived from varying methods.

**4.1.2. When conducting these ex-post cost analyses, we also struggled with a number of analytic challenges including establishing a clear counterfactual and disentangling costs incurred in response to a regulation from costs associated with other activities pursued simultaneously (e.g., system upgrades, product redesigns).**

**4.1.2.1. Do you have suggestions on ways to better meet these challenges?**

**4.1.2.2. Do you have any thoughts or recommendations on how EPA can estimate or better apportion costs across activities pursued by industry and differentiate between the regulatory driven and non-regulatory driven changes?**

**4.1.2.3. What should we do in cases where there is a real paucity of data that limits our analytic options? Are some methods of estimation more or less useful in these cases (e.g. expert opinion, maintain consistency with ex-ante; a rough estimate based on assumptions and publically available data)?**

Though simultaneous activities present a problem, it need not paralyze the analysis. Various assumptions could be used to bound the ex post cost estimates such as assigning all costs or some logical portion to arsenic as well as no portion to arsenic, then generating a range ex post cost estimates.

**4.1.3. Given the various data and analytic challenges, is it appropriate to draw “weight of evidence” conclusions on compliance costs based on the examination of key drivers of cost?**

**4.1.3.1. Are there cases where drawing conclusions is less or more defensible?**

**4.1.3.2. Some previous retrospective exercises have used hard metrics for evaluating whether costs are over or underestimated (e.g., Harrington et al. used +/- 25 percent). This same metric was applied in the case studies presented in the Interim Report. Should we continue to use this metric? What are the drawbacks, if any, to applying a consistent metric across the case studies given their differences in data quality?**

The standard used in the existing studies is not sufficiently informative as compared to providing the relative magnitude.

## 4.2. Methyl Bromide Case Study (Pete Wilcoxon)

### General Comments:

This study evaluates EPA's unit cost assessments for alternatives to the use of the ozone-depleting fumigant methyl bromide (MBr) by California strawberry farmers. The assessments are made in the course of national critical use exemption (CUE) requests to the Methyl Bromide Technical Options Committee (MBTOC), which operates under the auspices of the Montreal Protocol. CUEs allow a stipulated amount of MBr to be used when alternatives are infeasible or economically prohibitive. The MBTOC has allowed most of the requested CUEs and MBr continues to be used on much of the California strawberry crop. As a result, this study does not evaluate ex post costs in the usual sense because much of the industry has not had to adopt new practices. Rather, it attempts to determine whether subsequent information has generally confirmed or contradicted the original cost estimates.

It concludes that EPA's ex ante analysis was largely correct in two respects: forecasts of strawberry prices were close to actual prices, and estimates of harvesting costs are close to expert opinion in the form of typical crop budgets. Some differences arise in estimated cultivation costs, with EPA's ex ante estimates being higher than the corresponding crop budget figures. However, the largest difference arises in estimated yields: EPA's ex ante analysis assumes significantly larger losses than occur field trials of MBr alternatives. The analysis concludes that the ex ante and ex post estimates differ by more than the study's rough guideline of 25%.

**4.2.1. Each case study encountered a number of data-related challenges. Comprehensive, detailed data on compliance costs simply was not available for any of the case studies. In some cases, we obtained detailed data on compliance costs for a small segment of the affected industry. In others, we obtained aggregate level data for a larger proportion of the industry.**

**4.2.1.1. Under what conditions are different sources of ex-post data useful/not useful for assessing ex-post costs? In responding, please consider each of the following sources of data: aggregate information from states, data from demonstration projects, detailed data for a small portion of a heterogeneous industry, detailed data on what technologies have been adopted but unit costs for a "typical" entity, expert opinion on costs without external validation, cost estimates from contractors that worked on the original rule**

By design, the RCS uses only publicly available data, most of which is highly aggregated and none of which involved direct observations of strawberry farms. Key data include: strawberry prices; total acreage devoted to strawberry production; the fraction of acreage for which MBr exemptions were requested and on which MBr was used; the acreage using MBr alternatives; field trials indicating the effect of alternative fumigants on crop yields; crop budgets developed by the University of California-Davis for four locations in the state; and the prices of fumigants including MBr.

As corroborating evidence, the study presents aggregate data on the average productivity of strawberry farms in California, which does not appear to have fallen even though the percentage of the crop using MBr has declined over time. Moreover, the acreage under strawberry cultivation has increased

significantly and the rate of expansion does not seem to have diminished during the period MBr use has been declining.

However, a key limitation is that most of the evidence is circumstantial or based on what are essentially engineering-style theoretical estimates of potential performance of alternatives. As noted below, survey data from strawberry farms would strengthen the analysis considerably.

**4.2.1.2. Is there anything more we could do with the data we have for these case studies that would yield meaningful conclusions?**

The study makes good use of the information available for California. As noted below, it would be valuable to extend the analysis to Florida but that would require additional data that might be difficult to obtain.

**4.2.1.3. Do you have ideas on ways we can collect better ex-post information for these case studies given limited resources? Are there data sources we have not considered that we could use?**

For a conclusive ex post evaluation, it would be very valuable to add additional data based on the behavior of actual farmers. A survey of farms would be especially useful: done well, it would allow comparisons of new farms (which do not qualify for CUEs) and old farms, and for farms still using MBr with those that have substituted away from it. Such data would be particularly useful for quantifying the effects of alternatives on yields. It could also account for the development of different varieties of strawberries, and also take advantage of intrastate variations in regulations, such as township limits on the use of 1,3 D, to identify switching costs. In addition, a survey would allow measurement of the fixed costs of switching to alternatives, which may be significant but are not measured by either the ex ante or ex post evaluations.

A second option would be to expand the analysis to include Florida. It is clear that data for Florida is sparse and would be more difficult to obtain. However, the payoff would be large: there are fewer regulations that limit the adoption of alternatives, and the availability of CUEs are sharply different between the two states. Comparing California and Florida could provide a natural experiment that would help resolve the counterfactual question at the heart of the current analysis: what would strawberry farmers have done in the absence of MBr? Comparing the experience of tomato growers, who have also had to reduce the use of MBr, would be another possibility.

**4.2.2. When conducting these ex-post cost analyses, we also struggled with a number of analytic challenges including establishing a clear counterfactual and disentangling costs incurred in response to a regulation from costs associated with other activities pursued simultaneously (e.g., system upgrades, product redesigns).**

**4.2.2.1. Do you have suggestions on ways to better meet these challenges?**

In this case, the best opportunity to identify the costs of replacing MBr would be to take advantage of heterogeneity in regulation at the state and local level. As noted in the study, the rules on fumigant use vary considerably between states, and even between townships within the same state. Survey data collected from farmers could take advantage of that variation to separate regulatory effects from other changes in the industry.

**4.2.2.2. Do you have any thoughts or recommendations on how EPA can estimate or better apportion costs across activities pursued by industry and differentiate between the regulatory driven and non-regulatory driven changes?**

It will be extraordinarily difficult to separate these effects just using publicly-available and highly aggregated data. However, as noted above, detailed survey data that takes advantage of heterogeneity across regulatory jurisdictions would be very helpful.

**4.2.2.3. What should we do in cases where there is a real paucity of data that limits our analytic options? Are some methods of estimation more or less useful in these cases (e.g. expert opinion, maintain consistency with ex-ante; a rough estimate based on assumptions and publically available data)?**

Data limitations will always be a challenge but ex post evaluations still have much to contribute by helping to refine future ex ante calculations. In this case, even though data was very limited, the ex post analysis revealed that the ex ante estimates were far more sensitive to assumptions about yield losses than other variables. In retrospect, it seems clear that yield was the least well-understood component of the ex ante calculation. Carrying this approach further and tabulating: (1) the key components of the cost analysis; (2) the sources of ex post data; and (3) the relationship between the ex ante and ex post ranges of costs would be very valuable even with limited data. The table used to summarize the costs of regulations on locomotive emissions is a good example.

**4.2.3. Given the various data and analytic challenges, is it appropriate to draw “weight of evidence” conclusions on compliance costs based on the examination of key drivers of cost?**

**4.2.3.1. Are there cases where drawing conclusions is less or more defensible?**

Results from this study are useful and suggest that yield losses may be less than assumed in the analysis ex ante. However, to be conclusive regarding whether ex ante costs were biased, the assessment would need to be based on actual costs rather than crop budgets and field trials. There are many reasons why the practical performance of alternative fumigants and techniques might differ from what the budgets and trials predict, such as differences in soils, topography, microclimates, the use of tarps with varying permeability, or the quality of fumigant application. For example, the appearance of new diseases in non-MBr fields has caused some farmers who had switched to alternative fumigants to switch back to MBr once every few years.

**4.2.3.2. Some previous retrospective exercises have used hard metrics for evaluating whether costs are over or underestimated (e.g., Harrington et al. used +/- 25 percent). This same metric was applied in the case studies presented in the Interim Report. Should we continue to use this metric? What are the drawbacks, if any, to applying a consistent metric across the case studies given their differences in data quality?**

To conclude whether or not an ex ante estimate was biased rather than simply being imprecise, care must be taken to: (1) avoid hindsight bias by carrying out the evaluation using only information that was known or knowable at the time of the ex ante analysis, and (2) to account for the inherent uncertainties (and the associated confidence intervals) of both the ex ante and ex post estimates. For the latter, the ideal approach would be to construct confidence intervals for the ex ante and ex post analyses and test whether or not the hypothesis of bias could be rejected.

The use of the  $\pm 25$  percent threshold is a very rough approximation and may not be appropriate given the actual uncertainties in a given problem.

Avoiding hindsight bias is also important and can be more difficult: in this case, for example, some of the evidence on yields only became available later.

**4.3. Cluster Rule and MACT II Rule Case Studies (George Parsons and JunJie Wu)**

This study relies on publicly available data from the National Council for Air and Stream Improvement, Inc. (NCASI), which produced an annual survey of capital expenditures borne by pulp and paper firms until 2002. It also uses data found in the U.S. Securities and Exchange Commission (SEC) 10-K form, which provides some firm-level data for both ex ante and ex post costs of Cluster Rule compliance. However, comparisons across firms and over time is challenging because there is no template for submitting the data. The cost information on Maximum Available Control Technology (MACT) II and the implementation of a particulate matter (PM) bubble strategy was provided by Abt Associates / RTI International (see section below).

The RCS describes several issues that limit its ability to make firm conclusions: 1) for the Cluster Rule, the analysis only used industry level data, and the results are somewhat sensitive to the construction of the baseline; 2) for MACT II, the industry compliance expert provided the ex post cost information, this study could not independently verify the accuracy of the data; and 3) for MACT II the ex post cost data was estimated by a contractor. Insights offered herein should be viewed with these limitations in mind.

**4.3.1. Each case study encountered a number of data-related challenges. Comprehensive, detailed data on compliance costs simply was not available for any of the case studies. In some cases, we obtained detailed data on compliance costs for a small segment of the affected industry. In others, we obtained aggregate level data for a larger proportion of the industry.**

Under what conditions are different sources of ex-post data useful/not useful for assessing ex-post costs? In responding, please consider each of the following sources of data: aggregate information from states,

data from demonstration projects, detailed data for a small portion of a heterogeneous industry, detailed data on what technologies have been adopted but unit costs for a “typical” entity, expert opinion on costs without external validation, cost estimates from contractors that worked on the original rule.

Aggregate information from states (in this case industry groups) is OK if one is interested in a simple ex-post versus ex-ante overall comparisons. The problem is that you miss what really caused the differences in measurement (technology improvement, adopting lower cost alternative, etc.). You also have to be wary of how numbers are being reported (eg. missing operating cost, accounting for transaction costs, etc.). Supporting stories on what caused the differences underlying the data really help for understanding how to improve future practices.

We like the approach that uses detailed data on technologies adopted along with typical unit cost - it is like a ‘price and quantity’ approach. Get targeted detailed information on ‘price’ (unit cost) along with counts of changes in ‘quantity’ (new equipment or whatever) and multiple. Unit cost is hard to get and trying to build it up from some on-site actual data (instead of broad self-reported data) makes sense. Then, you can get the easier quantity count. The more heterogenous the industry the more sampling you have to do to get more unit costs. Unlike aggregate data you learn about what really happened and why the estimates are different.

As far as expert opinions go, we suggest that you evaluate and document what is available. With such limited information, we hate to see anything thrown away. Industry representatives and experts are close to the data and familiar with real circumstances in the trenches. They should be considered.

**4.3.1.1. Is there anything more we could do with the data we have for these case studies that would yield meaningful conclusions?**

**4.3.1.2. Do you have ideas on ways we can collect better ex-post information for these case studies given limited resources? Are there data sources we have not considered that we could use?**

This study could also be improved by establishing a more defensible timeline of regulatory process. The public comments provided by NCASI and others provide strong evidence that it is possible that the industry took some voluntary preemptive actions before 1995 given that the intention to regulate was signaled long before the promulgation of the cluster rule in 1998, and that the industry had made substantial investment before 1995 to reduce discharge. Given the large sums that were expended prior to the official promulgation of the rule, capital expenditures clearly made in anticipation of the regulation should be counted as the cost of complying with the regulations.

It seems that firm-level data exist from the NCASI annual survey of capital expenditures borne by pulp and paper firms however EPA has not gained access to those data. This analysis could be improved significantly with firm-level data (see response to charge question #5).

**4.3.2. When conducting these ex-post cost analyses, we also struggled with a number of analytic challenges including establishing a clear counterfactual and disentangling costs incurred in**

**response to a regulation from costs associated with other activities pursued simultaneously (e.g., system upgrades, product redesigns).**

**4.3.2.1. Do you have suggestions on ways to better meet these challenges?**

**4.3.2.2. Do you have any thoughts or recommendations on how EPA can estimate or better apportion costs across activities pursued by industry and differentiate between the regulatory driven and non-regulatory driven changes?**

**4.3.2.3. What should we do in cases where there is a real paucity of data that limits our analytic options? Are some methods of estimation more or less useful in these cases (e.g. expert opinion, maintain consistency with ex-ante; a rough estimate based on assumptions and publically available data)?**

The basic approach of this study is to compare capital expenditures made between 1995 and 1997 with those made between 1998 and 2001, and treat the difference as the ex post cost estimates.

There are several potential problems with this approach. First, it fails to take into account the preemptive, voluntary actions that the industry might have taken before 1995. Second, even if a correct timeline can be established, there is still a potential problem associated with the current approach. This study simply looks at capital expenditure before and after the promulgation of the cluster rule to deduce the cost of regulation. But many other things could potentially affect firms' investment decisions in addition to the regulation. For example, the economy was growing at 3.6% from 1995-1997, but 4.5% from 1998-2001. These external factors could potentially affect firms' investment decisions, but those effects would be attributed to the cluster rule under the current approach.

In short, the current approach is the source of enormous error in the Cluster Analysis. It all hinges how you handle the voluntary and pre-regulation compliance. If it is all attributed to the regulation, the costs are high, if not they are low. We think the simple truth here is that we do know for sure whether it belongs in or not. Short of having a natural experiment where we can sort this out, we suggest presenting sensitivity analysis making different assumptions - cases that include voluntary /pre-regulatory compliance and others that do not. This will convey the uncertainty and so the importance of the assumption.

Mill closure is also an important issue and deserves more attention. According to the RCS, of the 155 mills subject to the cluster rule, 15 mills had been closed by 2004, or about 10%. There is limited evidence that some of the closures were due to compliance, but the RCS concludes that mill closures alone cannot explain EPA's over-estimation of compliance costs. Even if this is true, mill closures still deserve more attention given the common belief that regulation kills jobs.

Finally, in directly comparing ex-post and ex-ante costs, it is important that both are using the same baseline and this was not clear to us that this was being done.

**4.3.3. Given the various data and analytic challenges, is it appropriate to draw “weight of evidence” conclusions on compliance costs based on the examination of key drivers of cost?**

**4.3.3.1. Are there cases where drawing conclusions is less or more defensible?**

**4.3.3.2. Some previous retrospective exercises have used hard metrics for evaluating whether costs are over or underestimated (e.g., Harrington et al. used +/- 25 percent). This same metric was applied in the case studies presented in the Interim Report. Should we continue to use this metric? What are the drawbacks, if any, to applying a consistent metric across the case studies given their differences in data quality?**

This RCS describes a number of issues that limit its ability to make firm conclusions. Given these problems, it is appropriate to draw “weight of evidence” conclusions on compliance costs only if the study could establish an appropriate and more defensible timeline of regulatory process. The conclusions drawn from this analysis would be more defensible if the EPA could gain access to the firm-level data and uses appropriate econometric techniques (e.g., difference-in-difference, propensity score matching method) to address self selection and other potential endogeneity issues.

We are less in favor of drawing a hard and fast line than reporting actual numbers – egs. 15% underestimate or 155% overestimate or even a range.

Going forward, it is important to keep the focus on what is learned in these ex post studies that will improve future ex ante analyses so social policy is formed with better information. For example, compliance flexibility can result in large cost savings which future analyses should be very sensitive to. Also, we see no reason why estimates should be purposely conservative. We believe they should be best estimates possible along with uncertainty bounds. It does not serve society well to purposely push the estimates one-way or the other. A simple honest reporting is best.

**4.4. Locomotive Emissions Case Study (Wayne Gray and Laura Taylor)**

**General Comments:**

In some cases, it may be possible to find a dataset containing sufficient information for an ex-post statistical analysis that would identify the costs of a new regulation, but this won’t usually be possible. Two major obstacles are the reluctance of firms to provide detailed data on production costs and the likelihood that other factors besides the regulation have changed. In the locomotive case study, firms were reluctant to cooperate by providing data on costs, and there were major changes in industry demand and diesel fuel prices.

It’s important for an ex-post analysis of regulatory costs to take a systematic approach to the process. Start with a “story” about the way(s) in which the industry was expected to achieve compliance (based on information from the ex-ante regulatory analysis), and connect this story to the various components that went into the ex-ante cost calculations. This provides a “bottom up” calculation for total industry costs. Then identify ways in which the actual industry experience was similar to or different from the ex-

ante expectations, including an assessment of how much of an impact (positive or negative) each difference would have had on compliance costs. This could include a discussion of the heterogeneity of responses among the firms in the industry, and factors other than regulation which affected the industry's level of activity. The end result would be at least a qualitative idea of whether actual compliance costs were significantly lower than expected, higher than expected, or similar - and why. Perhaps more importantly, it provides information that could be used to modify the methodology for future ex-ante estimates - or at least a healthy degree of skepticism about how much can be known in advance about how compliance will be achieved and other factors that will affect compliance costs. In the case of the 1998 locomotive emissions rule, the key compliance actions are changes in the design of the diesel engines used by locomotives, in order to reduce NOx emissions. This involves both purchasing new engines and remanufacturing old engines, and the regulatory requirements for engines differ, depending on when the engine was originally manufactured. The original ex-ante calculations identified the cost of the regulation in three pieces: the fixed costs to engine manufacturers of developing and certifying new types of engines, the increased variable costs of actually manufacturing the new engines, and the increased operating and maintenance costs for the railroads in running the new engines. Estimates of the per-engine costs were then multiplied by the expected number of engines of each type to get the total regulatory costs.

The locomotive case study did a nice job in following a systematic approach to the analysis. This was exemplified by their presentation slide (#63) which outlined 11 distinct components of compliance costs, the available sources of ex-post data for each component, and an assessment of whether that component had turned out to be larger or smaller than the ex-ante estimate. This systematic approach may have been easier for this rule, given its well-defined tiers of engines subject to different standards and information on the number of engines of each type in service, but it is still a model worth following. On the other hand, the ex-post data available for the actual calculations have serious limitations. The most obvious point is that there was virtually no industry cooperation in providing cost data. Nearly all of the ex-post cost information came from one engineer working for EF&EE, the company that had helped prepare the initial ex-ante cost analysis. Some corroboration was sought from other sources, including published journal articles, but the proprietary nature of actual cost data makes them difficult or impossible to obtain for ex-post analyses. Even when a useful dataset exists (such as the PartsLink database on the locomotive fleet mentioned in the RCS), they are likely to be too costly, given the limited budgets devoted to ex-post analyses. Expert opinion is likely to be the main source of data, and the experts with the most incentive to provide information are likely to be those who assisted in developing the ex-ante analysis.

There were also other factors that affected the regulatory costs, both directly and indirectly. The most obvious is the rise in diesel fuel prices. This directly affected the costs associated with losses in fuel efficiency. It indirectly affected costs by expanding the demand for rail transport, which is more fuel-efficient than trucking, shifting the incentives for railroads to purchase new locomotives rather than remanufacturing existing ones. It also provided incentives to improve fuel efficiency, so a simple comparison of fuel efficiency before and after the regulation would show improvements rather than the expected declines.

Despite these limitations, the locomotive case study is useful because of its systematic approach, breaking down the overall compliance costs into separate components and examining the available

evidence on how well the ex-ante analysis predicted each component. In that respect it is a model of how to conduct an ex-post analysis.

**4.4.1. Each case study encountered a number of data-related challenges. Comprehensive, detailed data on compliance costs simply was not available for any of the case studies. In some cases, we obtained detailed data on compliance costs for a small segment of the affected industry. In others, we obtained aggregate level data for a larger proportion of the industry.**

**4.4.1.1. Under what conditions are different sources of ex-post data useful/not useful for assessing ex-post costs? In responding, please consider each of the following sources of data: aggregate information from states, data from demonstration projects, detailed data for a small portion of a heterogeneous industry, detailed data on what technologies have been adopted but unit costs for a “typical” entity, expert opinion on costs without external validation, cost estimates from contractors that worked on the original rule**

Nearly all ex-post analysis will face serious data constraints, relative to “ideal” data, so whatever information is available should be used. It’s likely to be dependent on expert opinions provided by experts who helped prepare the ex-ante cost analysis, so using any available corroborating information would be helpful to confirm those expert opinions.

**4.4.1.2. Is there anything more we could do with the data we have for these case studies that would yield meaningful conclusions?**

The ex-post analysis used the available data in reasonable ways. One suggestion would be to identify cases where the industry behaved differently than expected, and use that information to look back at the original assumptions about costs. For example, the locomotive analysis assumed a fairly high fixed cost to develop and certify a new engine model, leading to the conclusion that few new models would be developed. In fact, many new models were developed, which could/should have raised the question of whether the fixed costs of model development may have been lower than expected.

**4.4.1.3. Do you have ideas on ways we can collect better ex-post information for these case studies given limited resources? Are there data sources we have not considered that we could use?**

One source of ex-post information could be regulatory staff (from both EPA and state agencies) involved in monitoring and enforcing compliance with the specific regulation. They should be able to identify how compliance has been achieved, for comparison with the ex-ante assumptions, and may have at least qualitative information on whether achieving compliance was more or less costly than expected.

**4.4.2. When conducting these ex-post cost analyses, we also struggled with a number of analytic challenges including establishing a clear counterfactual and disentangling costs incurred in response to a regulation from costs associated with other activities pursued simultaneously (e.g., system upgrades, product redesigns).**

**4.4.2.1. Do you have suggestions on ways to better meet these challenges?**

A useful first step is systematically breaking down the compliance costs into distinct components. Even when it's difficult to identify regulatory costs due to confounding factors (e.g. losses in fuel efficiency from regulation being offset by improvements due to higher diesel fuel prices), it might still be possible to identify the sensitivity of overall costs to uncertainties in measuring this particular component.

**4.4.2.2. Do you have any thoughts or recommendations on how EPA can estimate or better apportion costs across activities pursued by industry and differentiate between the regulatory driven and non-regulatory driven changes?**

Similar to 4.4.2.1 - be systematic about a bottom-up analysis. There are also conceptual issues, more relevant to the cluster rule and less relevant to the locomotive rule - how to count expenditures made in anticipation of the rule, or driven by concerns about public opinion rather than regulatory pressure.

**4.4.2.3. What should we do in cases where there is a real paucity of data that limits our analytic options? Are some methods of estimation more or less useful in these cases (e.g. expert opinion, maintain consistency with ex-ante; a rough estimate based on assumptions and publically available data)?**

There will almost always be a real paucity of data - wishing for better data or limiting the analysis to those few cases where good data exists is not productive. Most cases will involve applying expert opinion systematically to the components of regulatory costs, supported by whatever other data are available. Refocusing the RCS on broader questions about estimating regulatory costs rather than focusing on how much (if at all) the ex-ante analysis deviated from realized costs would likely be more useful for EPA.

**4.4.3. Given the various data and analytic challenges, is it appropriate to draw “weight of evidence” conclusions on compliance costs based on the examination of key drivers of cost?**

**4.4.3.1. Are there cases where drawing conclusions is less or more defensible?**

Yes, identifying which components of regulatory costs are the largest and seeing whether they were larger or smaller than expected seems a reasonable approach to an ex-post analysis. Having more or less uncertainty about the size of the components or the direction they went will naturally affect the “defensibility” of the ex post (and ex ante) estimates.

**4.4.3.2. Some previous retrospective exercises have used hard metrics for evaluating whether costs are over or underestimated (e.g., Harrington et al. used +/- 25 percent). This same metric was applied in the case studies presented in the**

**Interim Report. Should we continue to use this metric? What are the drawbacks, if any, to applying a consistent metric across the case studies given their differences in data quality?**

Again, a focus on whether costs are over or underestimated seems too simplistic, especially given the rich level of detail that can be generated about the compliance process and the impact of unexpected developments on compliance costs. Given that there are strong pressures to do the aggregate cost comparison, the 25 percent benchmark for a substantial/significant difference in estimates seems as good as any.

One long-run process suggestion would be to build some degree of ex-post analysis into the ex-ante process. Start by including in the ex ante analysis the main areas of uncertainty in regulatory cost in addition to a summary of the expected compliance techniques and the main components of regulatory cost. Regulatory staff assigned to monitor and enforce the new regulation could then be deployed to identify any obvious discrepancies between those ex-ante expectations and actual compliance methods and associated costs. This could be followed at some set interval (2 years, 5 years) by a brief ex-post analysis that summarizes the differences between expectations and actual outcomes, with a view towards improving future ex-ante analysis.

## 5. MOVING FORWARD

### 5.1. Using Ex Post Cost Comparisons to inform the Agency

5.1.1. It is difficult to make general statements about the accuracy of ex ante estimates of the costs of a regulation because the promulgation of every regulation is a unique event. Different considerations of timing, technology, industry structure, and a host of other factors go into the estimation of ex ante costs and determine the accuracy of those ex ante estimates relative to ex post experience. With this in mind, how can we meaningfully make generalizations concerning ex ante cost estimates based on ex post comparisons? How can ex post cost comparisons be used to inform how the Agency estimates costs ex ante for future rules?

**5.2. General Statements on the Bias of Ex Ante Estimates**

**5.2.1. Previous studies in the literature have focused on the relative proportions of over- and underestimates of costs or the average ratio of ex ante to ex post cost estimates. In section 3, we have suggested reasons for which these indicators might not reveal a bias in ex ante cost estimates, and have suggested a regression-based procedure for making such a determination.**

**5.2.1.1. Is it possible to make general statements as to the accuracy of ex ante cost estimates? If so, what might be the best way to evaluate their accuracy?**

**5.2.1.2. Is it appropriate to concentrate on the bias of ex ante cost estimates, or might other statistical measures be more revealing?**

### 5.3. Rules for Evaluation

The rules addressed in the Interim Report were selected so as to cover a range of media. Rules identified for Phase II of the project were randomly selected using stratified sampling. For both Phase I and Phase II rules, we have encountered (and continue to encounter) data challenges that make it difficult to draw conclusions regarding realized compliance costs. If we continue with this project, is there a way to credibly identify rules that would lead to informative ex-post cost studies from which we can draw conclusions? Specifically,

5.3.1. What should our priorities be with regard to how we select the sample of rules for evaluation? Should we compromise the random selection of rules in favor of selecting rules with more readily available data? If so, on what types of rules should we focus? What types of rules could we defensibly leave out? What kind of selection biases would we introduce under different sampling methods? For instance, if we exclude rules where the industry is particularly heterogeneous or data are difficult to identify, can we still draw conclusions that would be generally applicable?

5.3.2. How do we balance pragmatism vs. the purity of our sampling method, given our experiences (e.g., the challenges/limitations we have faced due to lack of participation by industry, an inability to identify industry compliance experts, potential contractor bias, and data limitations)? Should our choice of methodology inform the way we select the sample of rules or vice versa?

### 5.4. Building a Database

5.4.1. What additional suggestions do you have on how best to build a database of ex ante versus ex post cost comparisons of regulation given the difficulties we have faced thus far?

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## **APPENDIX A: CHARGE QUESTIONS**